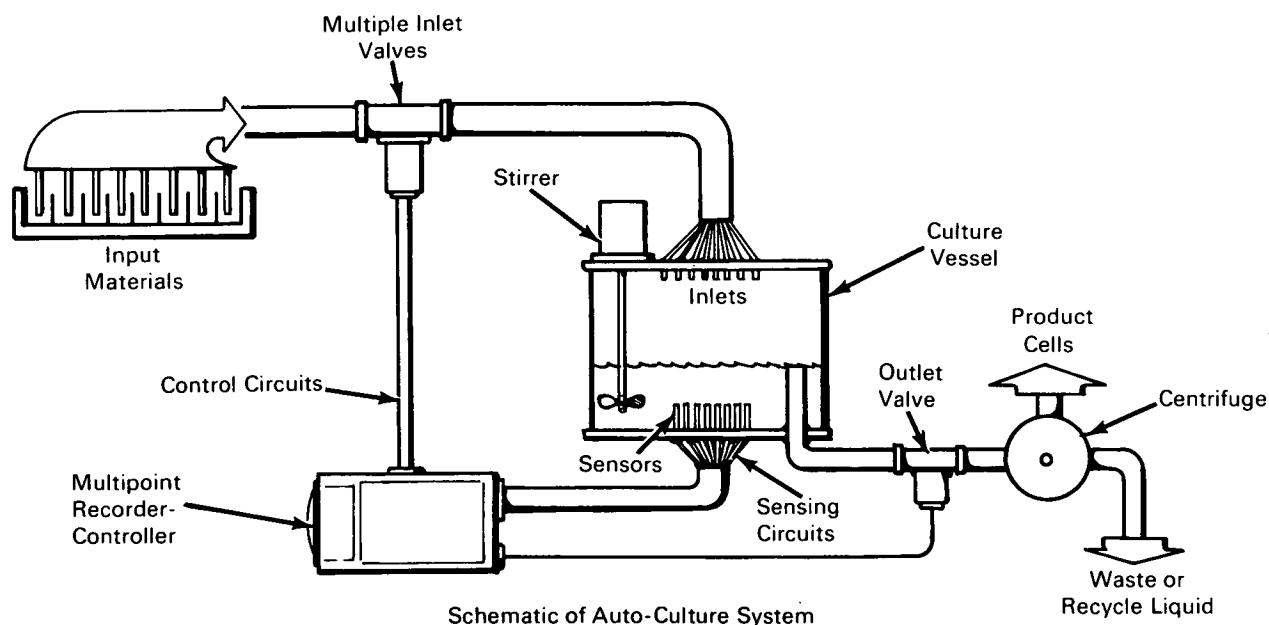


NASA TECH BRIEF



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Improved Apparatus for Continuous Culture of Hydrogen-Fixing Bacteria



Schematic of Auto-Culture System

An improved apparatus has been devised for continuous culture of *Hydrogenomonas eutropha*. This species of bacteria performs the intermediate process in a closed-cycle life support system that converts the human wastes urea and carbon dioxide, together with hydrogen and oxygen, into a cellular protein food source and water. Other steps of the cycle are the electrolysis of water to produce hydrogen gas and breathable oxygen, and the collection and recovery of carbon dioxide (CO_2) by a regenerable absorber. Only a part of the electrolytic oxygen is required to balance human consumption. The remainder of the oxygen, together with the hydrogen and the CO_2 , is returned to the culture vessel for use by the bacteria. Water produced by the bacterial metabolic process

is recycled to the electrolytic cell. The harvested cells are a potential food source. When the total system is in approximate balance, the only net input is electrical energy.

The apparatus for continuous culture of hydrogen-fixing bacteria incorporates three essential subsystems: 1) an environmentally isolated culture vessel, which contains a suspension of bacterial cells growing in a liquid medium and the mixture of carbon dioxide, oxygen, and hydrogen; 2) an analytical system with appropriate sensors and readout devices, which measures the value of each significant environmental variable in the culture vessel; and 3) a control system with feedback responses to each analytical measurement, which adds or removes materials or heat as needed to

(continued overleaf)

maintain selected environmental conditions. With modifications, the apparatus may be used to culture other microorganisms.

A schematic diagram of the continuous culture system appears in the figure. The quantitative value of each of the controlled variables in the environment of the continuous culture is monitored by an individual sensor, whose output is a specific function of the concentration or level of that variable. Partial pressure of carbon dioxide, hydrogen, and oxygen; pH; urea concentration; cell population density (optical density of the liquid medium at a wavelength of 650 m μ); temperature; and total pressure are the automatically controlled variables.

Signals from these sensors are scanned in sequence during a total time cycle of one minute. These signals are carried to a recorder-controller and recorded in the same sequence on a single chart. An individual control circuit is assigned to each recorded signal and is set to demand an addition of the appropriate material at a preset minimum concentration. The principle of incremental addition is used, in which a demand signal triggers the addition of a fixed, preset amount of the deficient environmental component. During the next minute, the concentration is again examined. Another increment is added if demanded. When the deficiency is satisfied, the concentration is recorded but nothing is added until the concentration again falls below the minimum.

When harvested, the cell suspension is centrifuged to separate the cells from their suspending nutrient medium. These cells are then resuspended in water and recentrifuged to wash out the associated urea and inorganic salts. Three such washes are necessary. Washed cell paste, with some further processing, may be converted into an acceptable protein-containing food supplement.

Notes:

1. This apparatus will be of interest to microbiologists engaged in research, development, and production in pharmaceutical laboratories; to engineers concerned with life support systems; to food technologists developing new food sources; and to nutritionists evaluating proposed dietary supplements. The apparatus also has pertinence to industries (particularly the petroleum industry) where waste gas conversion is critical.
2. Preliminary data on short-term oral administration of the purified cell paste to rats indicate that the bacteria have nutritional characteristics similar to casein and may be used as a dietary supplement.
3. The following documentation may be obtained from:

Clearinghouse for Federal Scientific
and Technical Information
Springfield, Virginia 22151
Single document price \$3.00
(or microfiche \$0.65)

References:

NASA-CR-1296 (N69-22766), Systems Approach to Evaluating *Hydrogenomonas* Cultures

NASA-CR-90111 (N68-10855), Engineering Requirements for Culturing of *Hydrogenomonas* Bacteria

Patent status:

No patent action is contemplated by NASA.

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